Chapter 8
Vegetation

PACIFIC ALUMINIUM

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8 Vegetation

This chapter provides a detailed assessment of the KGGP Project in relation to threatened flora species (listed under the TPWC Act), conservation significant species and vegetation communities. Conservation significant species are not Listed Threatened Species but are considered to be of conservation importance in the NT because of endemism and/or as potential indicators of landscape change (from changing fire regimes, for example). Potential impacts on Threatened flora species or Threatened ecological communities listed under the EPBC Act are addressed in detail in Chapter 10 (Matters of National Environmental Significance).

8.1 DESCRIPTION

A description of terrestrial and aquatic vegetation in the project area is provided, based on the results of a Vegetation and Flora Study (Appendix C). This Study is an update of a previous flora and vegetation report prepared for the Trans Territory Pipeline (TTP) Project (EcOz 2004b) and includes those findings and assessments relevant to the KGGP. This recent study assesses the relevance of any new site records that have been documented in relevant databases since 2004.

8.1.1 Study methodology

The Vegetation and Flora Study is based on a desktop review and the results of field surveys undertaken in 2003/04. Additional field surveys will be undertaken in 2013, the results of which will be provided in the Supplement to this Draft EIS.

Desktop review

The desktop review was undertaken to identify vegetation communities and flora species likely to occur in or near the pipeline corridor, particularly those that are listed as Threatened or are otherwise of conservation significance. The main data sources reviewed include:

- NT Herbarium Database records within a 10 km radius of the KGGP centreline (http://www.lrm.nt.gov.au/herbarium/requests).
- EPBC Act Protected Matters Search Tool within a 10 km radius of the KGGP centreline (http://www.environment.gov.au/epbc/pmst/index.html).
- Atlas of Living Australia (ALA) records within a 10 km radius of the KGGP centreline (http://www.ala.org.au).
- Department of Land Resource Management Threatened Species Information (http://lrm.nt.gov.au/biodiversity-conservation/animals/home/specieslist).
- Results from the EcOz 2003/04 field survey as presented in the Vegetation and Flora Study (Appendix C).
- The Vegetation of the Australian Tropical Savannas (1:2,000,000) (Fox *et al.* 2001).

At the time of the EcOz 2003/04 field survey and subsequent report (EcOz 2004), the Fox *et al.* (2001) classification was the only vegetation community data available for the NT. To remain consistent, this dataset is the predominant classification used for assessment in this Draft EIS. The more recent NVIS 2005 vegetation community mapping (DSEWPaC 2013c) is similar but at a smaller scale and has been used when more detailed information was required.

Field survey

The 2003/04 field survey was undertaken prior to the release of NT field survey guidelines, but methodologies were identified and developed in consultation with the Parks and Wildlife Commission NT. The structural classification used in the surveys generally followed the Australian Soil and Land Survey Field Handbook (McDonald *et al.* 1998).

The survey comprised 229 sites located at intervals of approximately five kilometres along the pipeline corridor. The field survey locations are shown in Figure 8-1 and Figure 8-2. The proposed sites for the above ground facilities and campsites will be surveyed during the 2013 dry season field survey.

Approximately 55 km of the pipeline corridor (KP345-KP360, Annie Creek to Goyder River) and (KP400-KP440, Mitchell Ranges), were not surveyed at the time. The environment traversed by these sections was assessed using desktop methods only. This area is targeted for survey during the 2013 dry season and the results provided in the Supplement to this EIS.

Vegetation communities described by Fox *et al.* (2001) and identified in the desktop review were confirmed during the field survey. The 2003/04 survey results include descriptions of these communities based on floristic data observed in the field. For consistency, however, descriptions developed by Fox *et al*. (2001) are used throughout this chapter, with the exception that the 'monsoon' preface on many community notations has been removed. This notation was used by Fox *et al*. (2001) to differentiate these communities from those occurring in the eastern sub-humid zone of the tropical savannas.

The linear nature of the pipeline corridor necessitated a flexible survey methodology that allowed for increased sampling where complex vegetation patterns occurred, and decreased sampling where vegetation was relatively homogenous over long distances. Sampling was generally undertaken at intervals of five kilometres in a continuous traverse, unless a vegetation community of specific interest was identified, and then additional site information was recorded.

Limitations of the field survey

The field surveys were done during the late dry season of 2003 and the mid-dry season of 2004. The dry conditions at the time of the surveys led to the absence of many of the annual species that typically occur in the understorey of the vegetation communities surveyed. One-fifth of the surveyed communities had been burnt within the six month period prior to the field surveys and some communities had been burnt so recently that no understorey species remained for identification. Both the dry conditions and fire reduced the likelihood of locating all plant species occurring in the understorey, especially herbaceous and/or annual species. This did not impact the likelihood of locating three of the four species listed as Threatened, nor the conservation significant species, which are shrubs and/or trees.

8.1.2 Study results—terrestrial vegetation

Vegetation communities

The vegetation in the project area is characterised by eight broad vegetation groups (BVGs) and 12 vegetation units (VUs) as defined by Fox *et al*. (2001). These BVGs are shown in Figure 8-3 and include:

- Woodlands and open-woodlands dominated by *Eucalyptus tetrodonta* and *E. miniata*.
- Open forests and woodlands dominated by *Eucalyptus spp*. and *Corymbia spp*. on drainage lines and alluvial plains.
- Woodlands dominated by *Eucalyptus tectifica* and *Corymbia spp*.
- Low woodlands to open woodlands dominated by *Corymbia dichromophloia*.
- Woodlands dominated by *Eucalyptus pruinosa* and *Bauhinia cunninghamii*.
- *Acacia shirleyi* and *Acacia spp*. associations on dissected residual surfaces and sandstone hill.

Figure 8-1: Field survey locations (Katherine end of the pipeline)

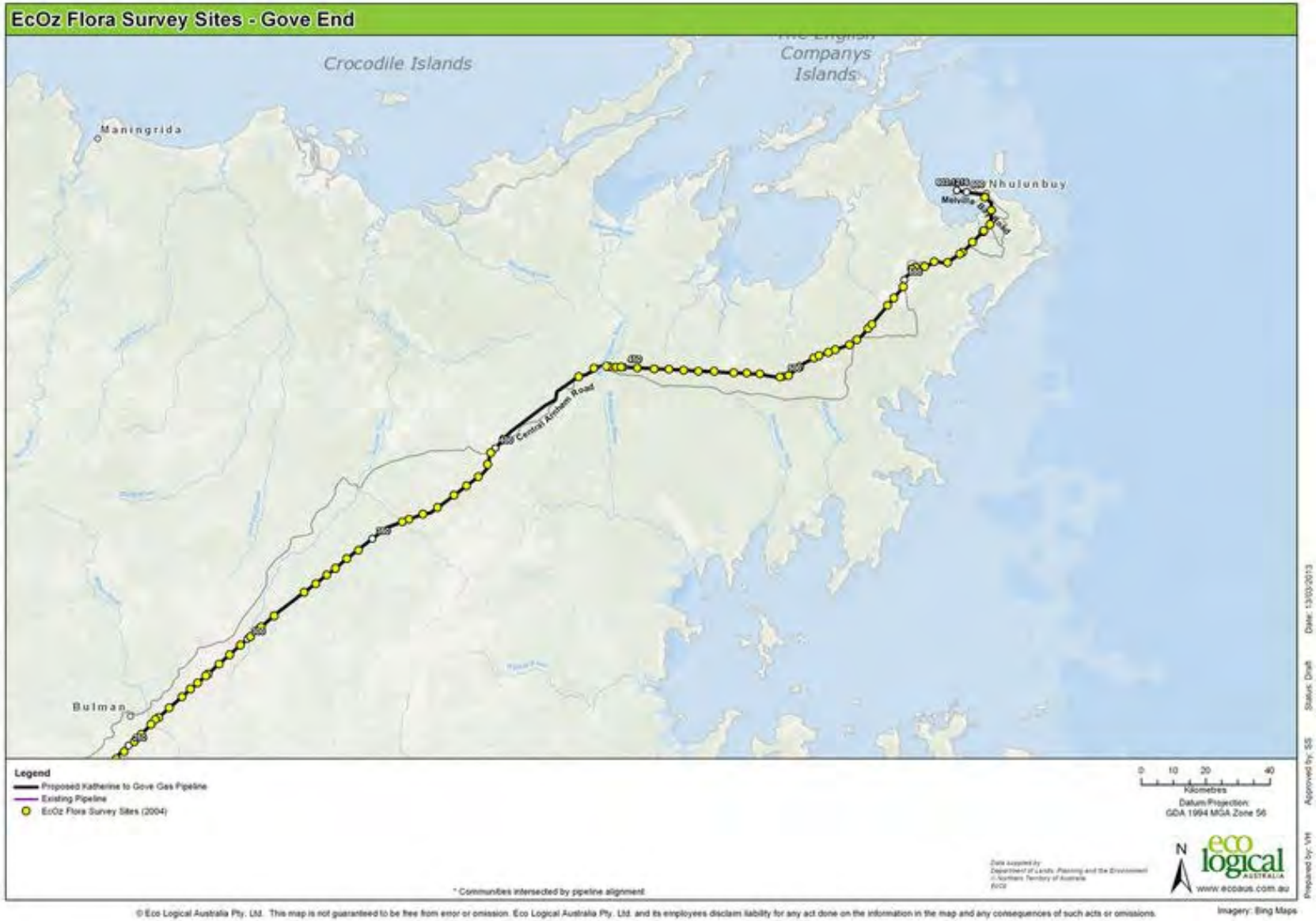

Figure 8-2: Field survey locations (Gove end of the pipeline)

- Tussock grasslands.
- Open forests and woodlands of *Melaleuca spp*. associated with rivers, lagoons and swamps.

The relationship between these vegetation groups (and associated vegetation units) and the pipeline ROW are discussed further in Section 8.3.

The surveyed vegetation patterns occurring along the route traversed by the KGGP from west to east are briefly described in Table 8-1.

Table 8-1: Vegetation patterns along the route traversed by the KGGP as surveyed in 2003/04*.

PIPELINE KP	VEGETATION DESCRIPTION
0-60	Gently undulating sandy plains dominated by *Eucalyptus tetrodonta* open forest often with *Corymbia bleeseri, C. dichromophloia, C. latifolia* and *Erythrophleum chlorostachys*, and tussock grasses in the understorey.
60-84 (Waterhouse River)	Undulating plains dominated by *Eucalyptus tectifica* and *Corymbia latifolia* open woodland to woodland with *Themeda triandra, Heteropogon contortus* and *Sarga* spp. tussock grasses in the understorey. The plains are dissected by channels of Beswick Creek and Waterhouse River with fringing forests dominated by *Melaleuca* spp. and *E. camaldulensis* and a dense mid storey of species such as *Pandanus aquaticus* and *Barringtonia acutangula.*
84-120	Low sandstone hills and rises with areas of rugged dissected plateaux and rocky ridges dominated by either *Eucalyptus miniata* and *E. tetrodonta* forest with *E. phoenicea* and *Corymbia bleeseri,* or *C. latifolia, E. tectifica* and *C. foelscheana* open woodland, both with tussock grasses in the understorey. The broad fluvial corridor associated with the Chambers River meanders through the hills and is dominated by a fringing forest of *E. camaldulensis*.
120-200	Level to gently undulating plains with clay soils dominated by *Eucalyptus tectifica* and *Corymbia latifolia* woodland with a variety of co-dominant species in the understorey including *Mnesithea rottboellioides, Arundinella nepalensis, Heteropogon contortus* and *Schizachyrium fragile*. The plains are dissected by broad fluvial corridors and low hills and rises on siltstone which are dominated by *Melaleuca* spp. and *E. pruinosa* open woodland with a sparse understorey of tussock grasses and *Eriachne* spp.
200-230	Gently undulating to hilly terrain on basalt, and low hills and rises on siltstone, both dominated by open woodlands of *Eucalyptus patellaris, Corymbia confertiflora, C. terminalis, C. bella* and *E. tectifica,* with tussock grasses in the understorey. *Melaleuca spp.* open woodlands with *Triodia* spp. and *Sarga* spp. grasses in the understorey occur in wetter areas. Broad fluvial corridors are associated with the Mainoru River and Wilton River. The fringing forests are dominated by *Melaleuca cajuputi* closed forest and *Casuarina cunninghamiana* and *Lophostemon lactifluus* respectively.
230-432*	Undulating slopes with rises and low hills, dominated by *Eucalyptus miniata* and *E. tetrodonta* woodlands to open forests with *Petalostigma quadriloculare, Triodia* spp., *Sarga* spp. and *Eriachne* spp. in the understorey. East of the Wilton River the country grades into gently undulating sand plains dominated by *E. miniata* and *E. tetrodonta* woodlands to open forests, sometimes with *Callitris intratropica*. The vegetation has a notably dense shrubby understorey dominated by a variety of species including *Pachynema complanatum, Acacia* spp., *Fimbristylis* spp., *Hibbertia dealbata, Schizachyrium fragile* and *Triodia* spp. (Spinifex).

PIPELINE KP	VEGETATION DESCRIPTION
	Isolated swamp depressions and alluvial floodplains associated with the Annie Creek and Goyder River systems typically support *Melaleuca* spp. closed forests with *Eriachne* sp. in the understorey. The fringing riparian forests are dominated by *Melaleuca* spp. with *Pandanus aquaticus, Acacia leptocarpa* and *Barringtonia acutangula.*
432-442* (Mitchell Ranges)	Elevated rocky plateaux and rolling to steep hills dominated by open woodland of Eucalyptus tetrodonta, E. miniata, E. phoenicea and Callitris intratropica. Source: Lynch and Wilson 1998).
442-540 (Cato River)	Gently undulating sandy plains dominated by Eucalyptus tetrodonta and E. miniata woodlands to forests with tussock grasses in the understorey. The sandy plains are dissected by floodplains and channels associated with the Goromuru River, Boggy Creek and the Cato River, which are dominated by forests of Melaleuca viridiflora and Lophostemon lactifluus with Imperata cylindrica and other sedge species in the understorey.
540-603 (Gove Refinery)	Gently undulating plains associated with bauxite, dominated by Eucalyptus tetrodonta woodland to forest with Sarga spp. tussock grasses in the understorey. Eucalyptus miniata is notably absent as a co-dominant in the vegetation east of the Cato River. The plains are dissected by narrow floodplains and channels associated with the Giddy River, Latram River and coastal inlets on the east coast of the Gove Peninsula, which are typically dominated by closed forest of Melaleuca spp., Corymbia polycarpa and Lophostemon lactifluus with Imperata cylindrica in the understorey.

Note that areas at approximately KP345-KP360 (Annie Creek to Goyder River) and KP400-KP440 (Mitchell Ranges) were not surveyed in 2003/04.

Geographically restricted vegetation communities including riparian corridors, wetlands (swamps and floodplains), monsoon vine forests and sandstone communities occur within the dominant *Eucalyptus*/*Corymbia* woodland matrix but are not accurately represented in the vegetation classification prepared by Fox *et al*. (2001). These communities, because of their restricted distribution, and associated value as habitat for fauna with distinct habitat requirements, are of high conservation value and are discussed in Chapter 9.

Threatened flora species

Database searches and a review of the distribution and habitat requirements of plant species listed under the TPWC Act and EPBC Act identified five Threatened plant species that may occur in the pipeline region:

- Arenga Palm (*Arenga australasica)*.*
- *Cycas armstrongii**.*
- *Hernandia nymphaeifolia.*
- *Pternandra coerulescens.*
- *Sticherus flabellatus* var. *compactus.*

* *While database searches suggested that the Arenga Palm (*Arenga australasica*) may occur in the pipeline region, a recent review indicates that this species only occurs in Queensland (I. Cowie, Department of Land Resource Management, pers. comm. February 2013). The NT taxon is no longer regarded as* A. australasica*, but* A. microcarpa*, which has no status under EPBC Act. For further discussion regarding this species see Chapter 10.*

*** Considered to most likely be an incorrect record.*

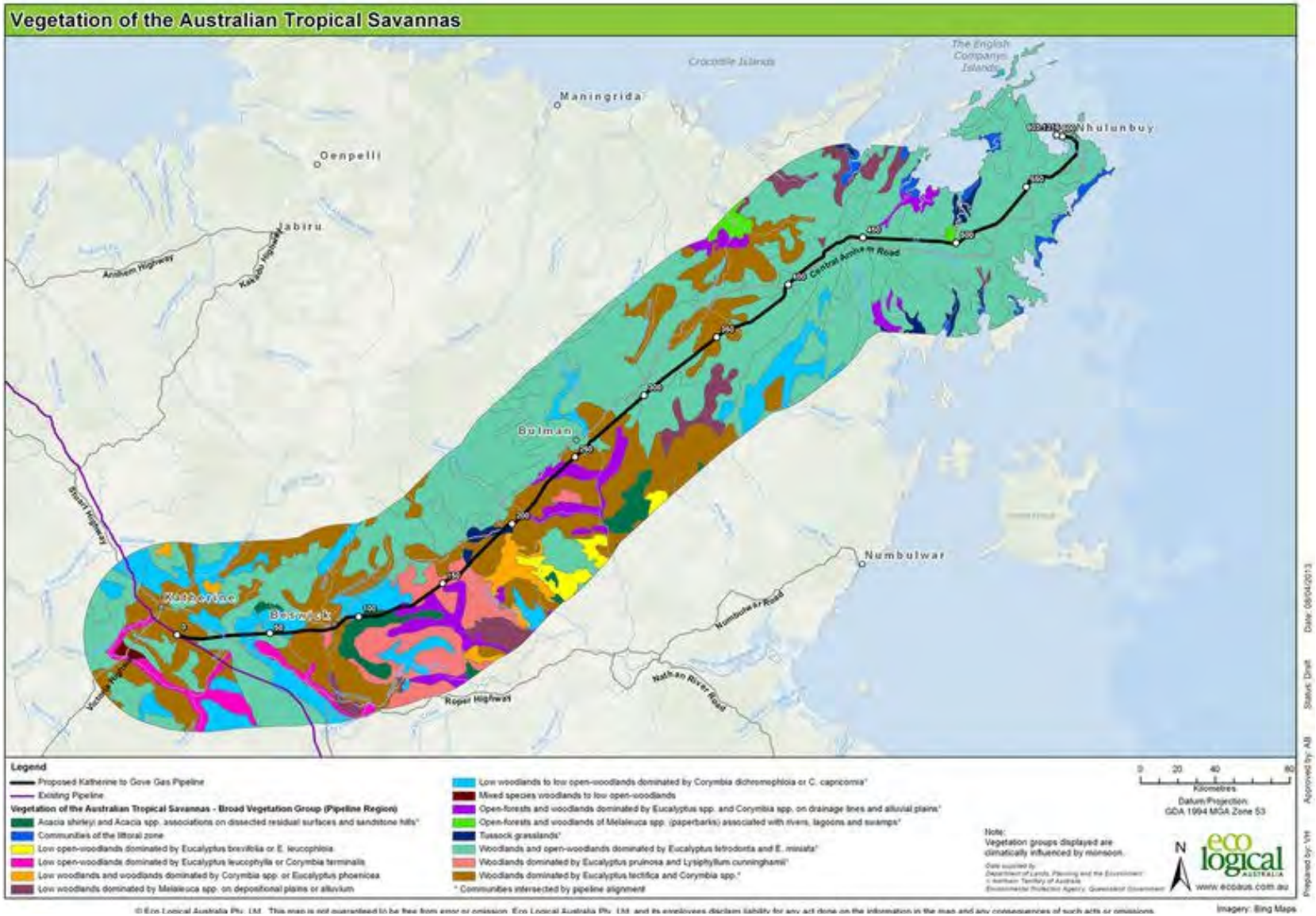

Figure 8-3: Vegetation of the Australian Tropical Savannas (Broad Vegetation Groups) within the pipeline region

None of these species were recorded during field surveys. For reasons noted above *Arenga australasica* and *Cycas armstrongii* are not discussed further. The conservation status, distribution and habitat preferences of the three remaining Threatened species are provided in Table 8-2 and discussed further below.

While dry and fire-affected conditions were evident throughout the field survey, it is considered that this only affected the likelihood of locating the small terrestrial fern *Sticherus flabellatus* var. *compactus.* The fern is known from one locality in the NT with two records located less than 10 km from the pipeline. Its habitat (sandstone cliffs in riparian vine forests in the NT and damp river banks and other wet places in Queensland) is generally fire protected.

Desktop searches and review identified a further 22 species listed as Near Threatened and 53 species listed as Data Deficient under the TPWC Act within the pipeline corridor (refer to Appendix C for the full list of species).

Ecological background regarding the biology, population and potential threats to the Threatened flora species listed as possible or likely to occur is described below.

Hernandia nymphaeifolia is a shrub or tree ranging in height from 5 - 22 m which occurs exclusively along the sea-shore in littoral forest and coastal swamps in coastal areas (Kerrigan and Cowie 2006a). It has been recently recorded from the coast in eastern Arnhem Land (Figure 8-4), however, was not recorded during field survey. Kerrigan and Cowie (2006a) identify stochastic events such as cyclones as potential threats to this species.

Pternandra coerulescens is typically either a medium tree, or a several-stemmed erect rambling shrub that inhabits spring-fed rainforests and riparian forest communities (Kerrigan and Cowie 2012). It is known from approximately six localities in northeast Arnhem Land, including confirmed locations at the Latram River, Giddy River (and two of its tributaries) as well as at two upper tributaries of the Cato River (Kerrigan and Cowie 2012) (Figure 8-5). *Pternandra coerulescens* has previously been recorded from a location 750 m south-east of where the pipeline corridor would cross the Latram River (KP582), however, surveys in 2004 of the Latram River at the proposed HDD pipeline crossing did not identify any specimens. Single populations are known to extend for about four kilometres of stream bank but otherwise populations are sparse and scattered (Kerrigan and Cowie 2012). Potential threats to *P. coerulescens* include those from cyclonic events and changes to hydrology due to water extraction for growing local domestic supply and industrial uses (Kerrigan and Cowie 2012). The impact of current fire regimes and feral animal activity is largely unknown, although plants that occur along some streams may be subject to scorching from dry season fires (Kerrigan and Cowie 2012).

Sticherus flabellatus var. *compactus* is a small terrestrial fern. This variety of *Sticherus flabellatus* is known from northeastern Queensland and only one locality in northeastern Arnhem Land in the NT consisting of sandstone cliff in riparian vine forests (Kerrigan and Cowie 2006). Two records of the species occur within the project area (Figure 8-6); however, this species was not recorded during field survey. Classified as a small population (<1000 individuals) with a restricted area of occupancy, this species is susceptible to stochastic events including forest canopy destruction from cyclones; however, changes to hydrology and infestation from exotic weeds may also potentially threaten this species (Kerrigan and Cowie 2006).

Table 8-2: Threatened plant species identified through database searches as occurring within the KGGP region

SPECIES	STATUS[#]		PREFERRED HABITAT AND DISTRIBUTION	LIKELIHOOD OF OCCURRENCE
	TPWC	EPBC		
Hernandia nymphaeifolia	V	--	A shrub/tree 5 – 22 m tall. Occurs exclusively in coastal areas along the sea-shore in littoral forest and in coastal swamps (Kerrigan and Cowie 2006a). Known from Groote Eylandt and Port Bradshaw in north-east Arnhem Land (Kerrigan and Cowie 2006a).	**Possible**. Habitat is exclusive to coastal areas, potential habitat located at the far eastern extent of the pipeline at approximately KP568.
Pternandra coerulescens	V	--	A shrub/tree 6 – 15 m tall. Spring-fed rainforests, the banks of spring fed streams and in riparian forests (Kerrigan and Cowie 2012). Known from approximately six localities in north-east Arnhem Land (Kerrigan and Cowie 2012).	**Likely**. Habitat is present within pipeline corridor, ten known records <2 km from the pipeline alignment at approximately KP556 – 581.
Sticherus flabellatus var. *compactus*	V	-	Terrestrial fern. In the NT, the species is known from only one locality in north-eastern Arnhem Land, with a habitat preference for sandstone cliffs in riparian vine forests (Kerrigan and Cowie 2006). Also occurs in north-eastern Qld.	**Possible**. Habitat is present within pipeline corridor, two known records <10 km from the pipeline alignment at approximately KP565.

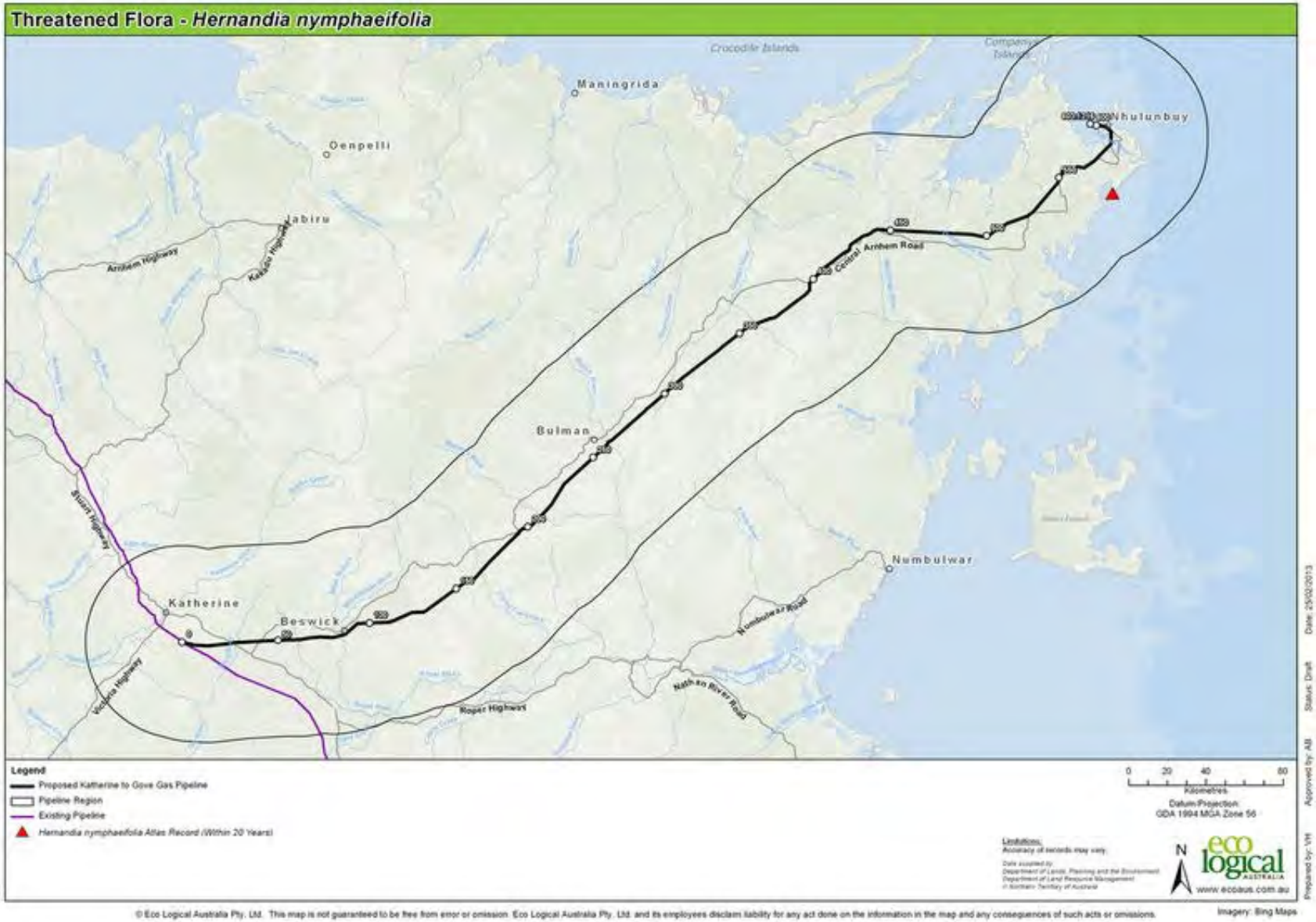

Figure 8-4: Location of *Hernandia nymphaeifolia* within the pipeline region

Figure 8-5: Location of *Pternandra coerulescens* within the pipeline region

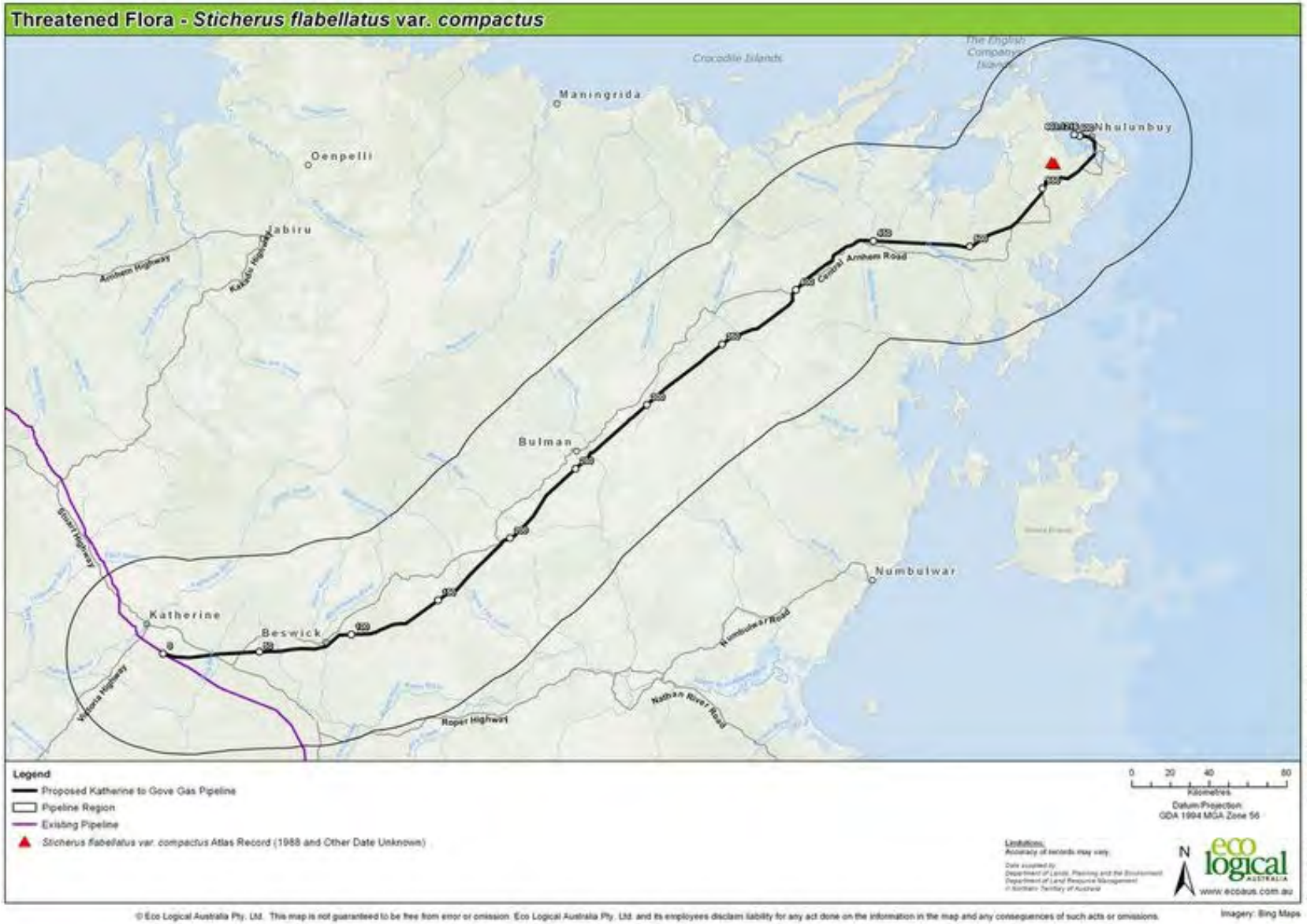

Figure 8-6: Locations of *Sticherus flabellatus* var. *compactus* within the pipeline region

Other species of conservation significance

Other flora species of conservation significance recorded in the project area include the Northern Cypress Pine (*Callitris intratropica*) and two cycad species (*Cycas orientis* and *C. arnhemica*).

Callitris intratropica currently occupies only a fraction of its potential range and has experienced a widespread collapse due to the impact of contemporary fire regimes (Bowman and Panton 1993). *Callitris intratropica* is a fire-sensitive, obligate seeder (Russell-Smith 2006) and often occurs in even-aged stands, indicating a cohort that grew following a low intensity fire event. In the absence of low intensity, patchy fire events, *C. intratropica* distributions are contracting (Bowman *et al*. 2001; Russell-Smith 2006) and stands of this species are becoming more infrequent within the landscape.

Callitris intratropica was observed at a number of locations during field survey (Appendix C), along the proposed pipeline corridor and at a site near the Buckingham River proposed for a construction camp (Camp 4). Observations ranged from large trees scattered through *Eucalyptus* woodland/forest communities to small homogenous patches consisting of both mature individuals and juveniles. Dead trees were observed at a number of locations mainly in flat *Eucalyptus* woodland/forest communities on sandy soils. The distribution of *C. intratropica* is becoming restricted to locations where seedlings are able to escape the impacts of fire (including rainforest margins, and fire-protected microsites within savanna such as rocky outcrops and drainage lines) (Bowman *et al.* 2001; Russell-Smith 2006) following land management changes that shifted fires from low intensity, patchy burning to widespread high intensity wildfires (Whiteside and Taplin 2010).

Scattered *Cycas orientis* and *C. arnhemica* trees were recorded in the project area in *Eucalyptus* woodland/forest communities located east of the Goyder River through to northeast Arnhem Land where they commonly formed a significant component of the understorey vegetation in some communities (Appendix C). Cycads are typically slow growing, and have a localised distribution. Little is known about their ecology, and their response to threats such as land clearing and contemporary fire regimes (Liddle 2009). There are ten cycad species that are all regionally endemic to the NT. The NT Government through the Management Program for Cycads 2009-2014 (Liddle 2009) has committed to taking the potential local and regional effects on the status of cycad populations into account in considering land clearing and other development applications.

Weeds

Field survey recorded 20 weed species in the project area. A further ten species have been identified during desktop review as being of potential concern and likely to occur in the project area (Appendix C).

Weed distribution in the project area at the time of field surveys was generally related to environmental disturbances caused by the construction of existing roads and tracks, cattle grazing and feral animals. Weeds were most prevalent on land under pastoral lease, and on the freehold properties in the Katherine region. In these areas infestations were generally concentrated around infrastructure such as water points, fence lines and tracks, and also along the banks of watercourses where cattle and feral animals tend to congregate.

Twenty-three of the species identified in the project area are declared weeds under the NT *Weeds Management Act*. Weeds of National Significance (WONS) (Australian Weeds Committee 2012) recorded in the project area during field survey include Prickly Acacia (*Acacia nilotica*) (Figure 8-7) and Parkinsonia (*Parkinsonia aculeata*) (Figure 8-8), both of which were recorded on Mainoru Station. Mimosa (*Mimosa pigra*), another WONS species, is also known to occur within the pipeline region (Figure 8-9).

Species classified as WONS and listed as Class A, B and/or C weeds under the NT *Weeds Management Act* include Gamba Grass (*Andropogon gayanus*) (Figure 8-10), Bellyache Bush (*Jatropha gossypifolia*) (Figure 8-11) and Lantana (*Lantana camara*) (Figure 8-12). Mission Grass (*Cenchrus polystachion*) is not a WONS species but is listed as Class B and C under the NT *Weeds Management Act* and was recorded during field survey (Figure 8-13). A full list of the weed species recorded or likely to occur in the project area is provided in Appendix C.

Major weed infestations will be confirmed during the 2013 dry season survey using the results from both the desktop review and field survey.

8.1.3 Study results—aquatic vegetation

Plant communities in submerged environments that occur in the project area can be divided into two basic categories: those that live in waters with a high amount of dissolved solids, such as the Mainoru River, and those that live in waters with very small amounts of dissolved solids (i.e. relatively clear waters). The majority of the waters to be crossed by the pipeline corridor fall into the latter category. Aquatic flora recorded during the field surveys are listed in Appendix C. The only flora of note belong to the *Utricularia* genus, of which 34 species occur in the Top End, making it the third largest concentration of *Utricularia* species in the world (Cowie et al. 2000). No Threatened aquatic flora species were identified within the pipeline corridor.

8.2 POTENTIAL IMPACTS OF CONSTRUCTION AND OPERATION

This section summarises the potential impacts that may directly or indirectly affect vegetation within and surrounding the project area.

The impact assessment undertaken to meet the EIS Guidelines (Appendix P) required all potential environmental impacts to be subjected to a risk assessment. The risk assessment and the methodology underlying the assessment of risk to vegetation from potential impacts of construction and operation are described in Chapter 5.

This impact assessment addresses the following construction and operation components (see Chapter 2 for a full description of the project):

- Construction and operation of a 603 km buried pipeline commencing approximately 20 km south of Katherine and extending to the Gove refinery.
- Construction and operation of ancillary support infrastructure including:
  - Compressor station.
  - Scraper stations, main line valves and meter stations.
  - Access roads and upgrade of existing road systems.
  - Construction camps.
- Maintenance of the pipeline.
- Maintenance of ancillary support infrastructure.

The environmental aspects of the project with the potential to impact on vegetation include:

- Vegetation clearing.
- Introduction and spread of exotic species.
- Fire ignition – increased risk of fire leading to altered frequency or spatial distribution of fire in the landscape.
- Additional aspects including:
  - Vehicular movements.
  - Dust emissions.

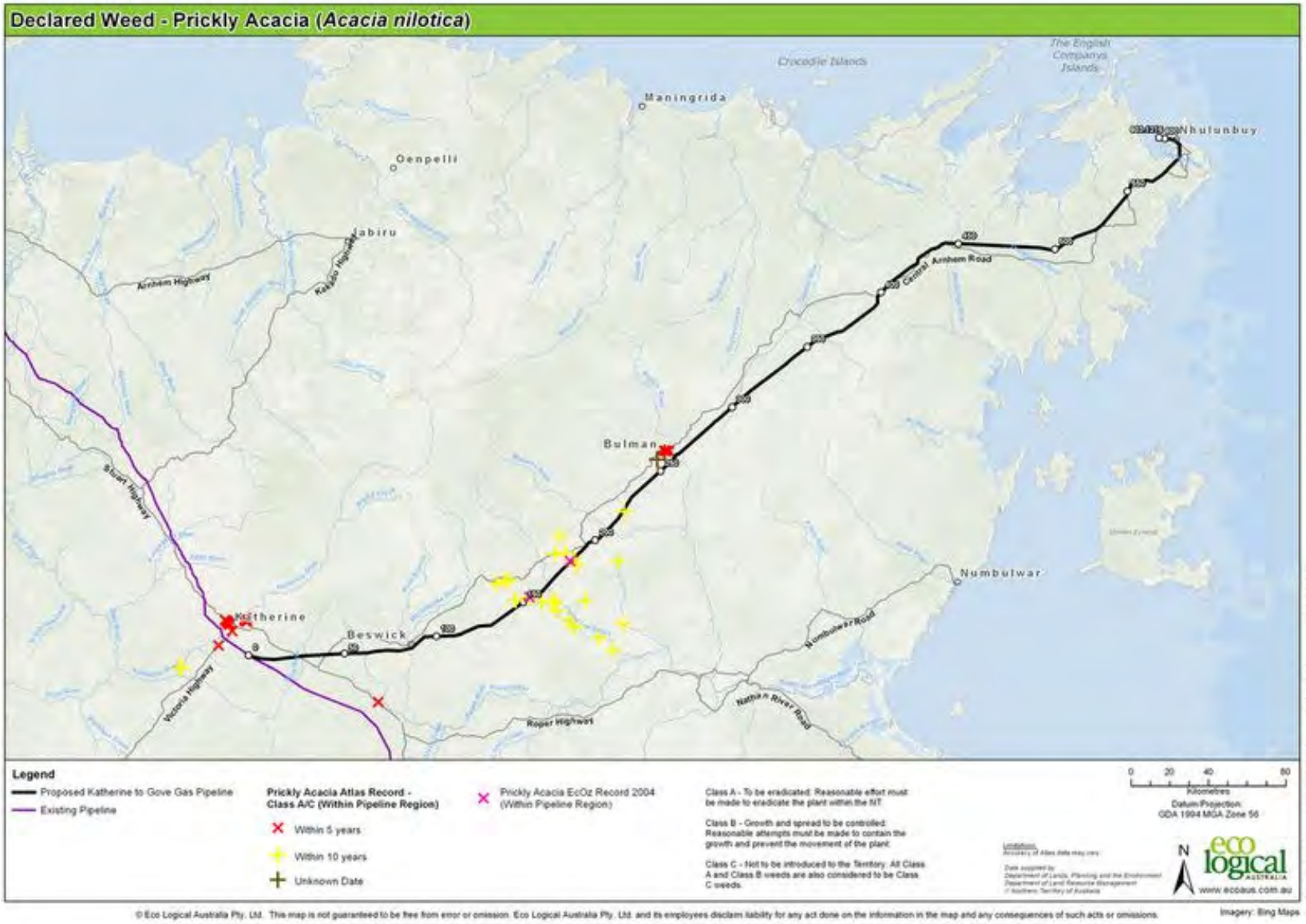

Figure 8-7: Location of Prickly Acacia within the pipeline region (including field survey locations)

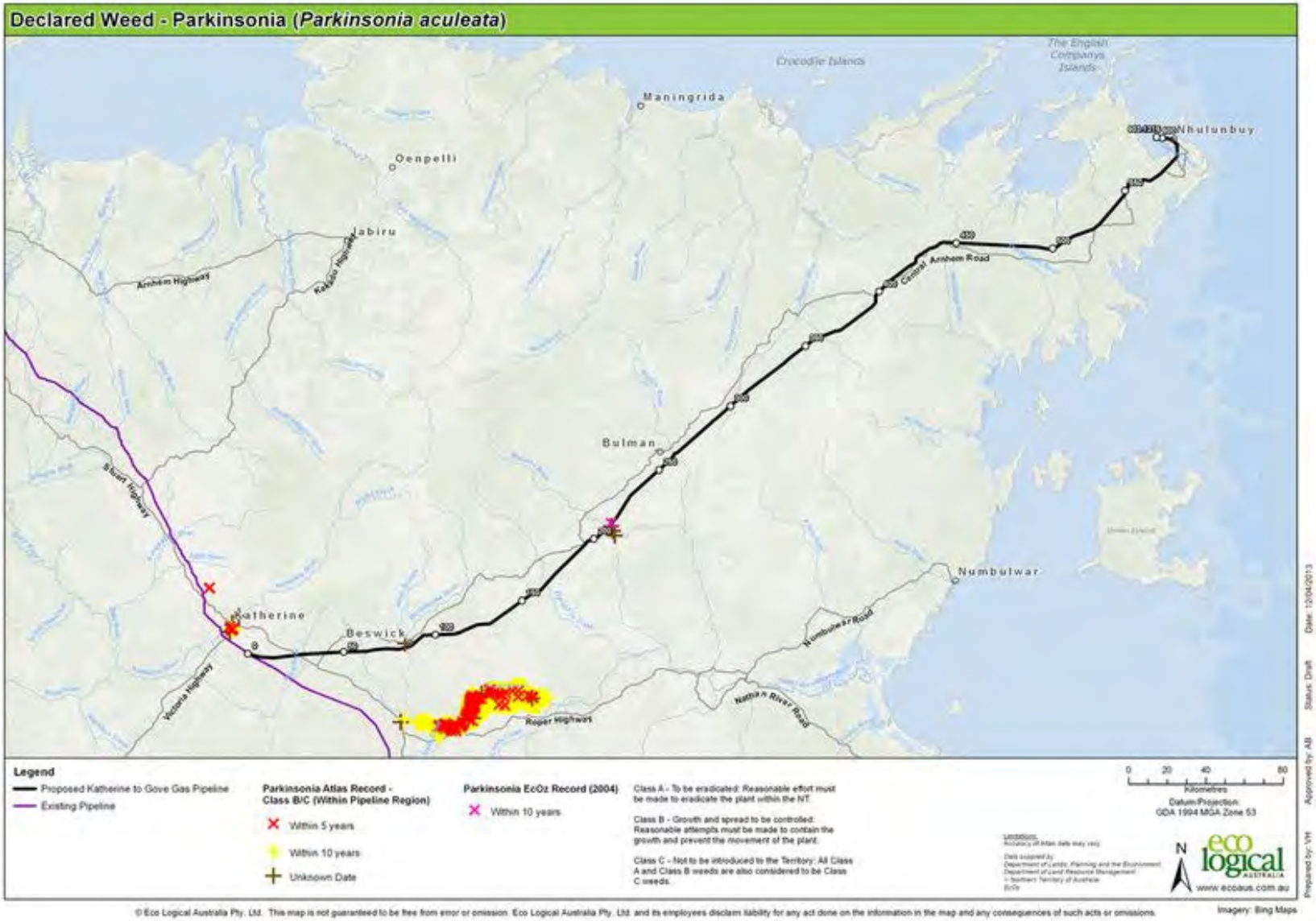

Figure 8-8: Location of Parkinsonia within the pipeline region (including field survey locations)

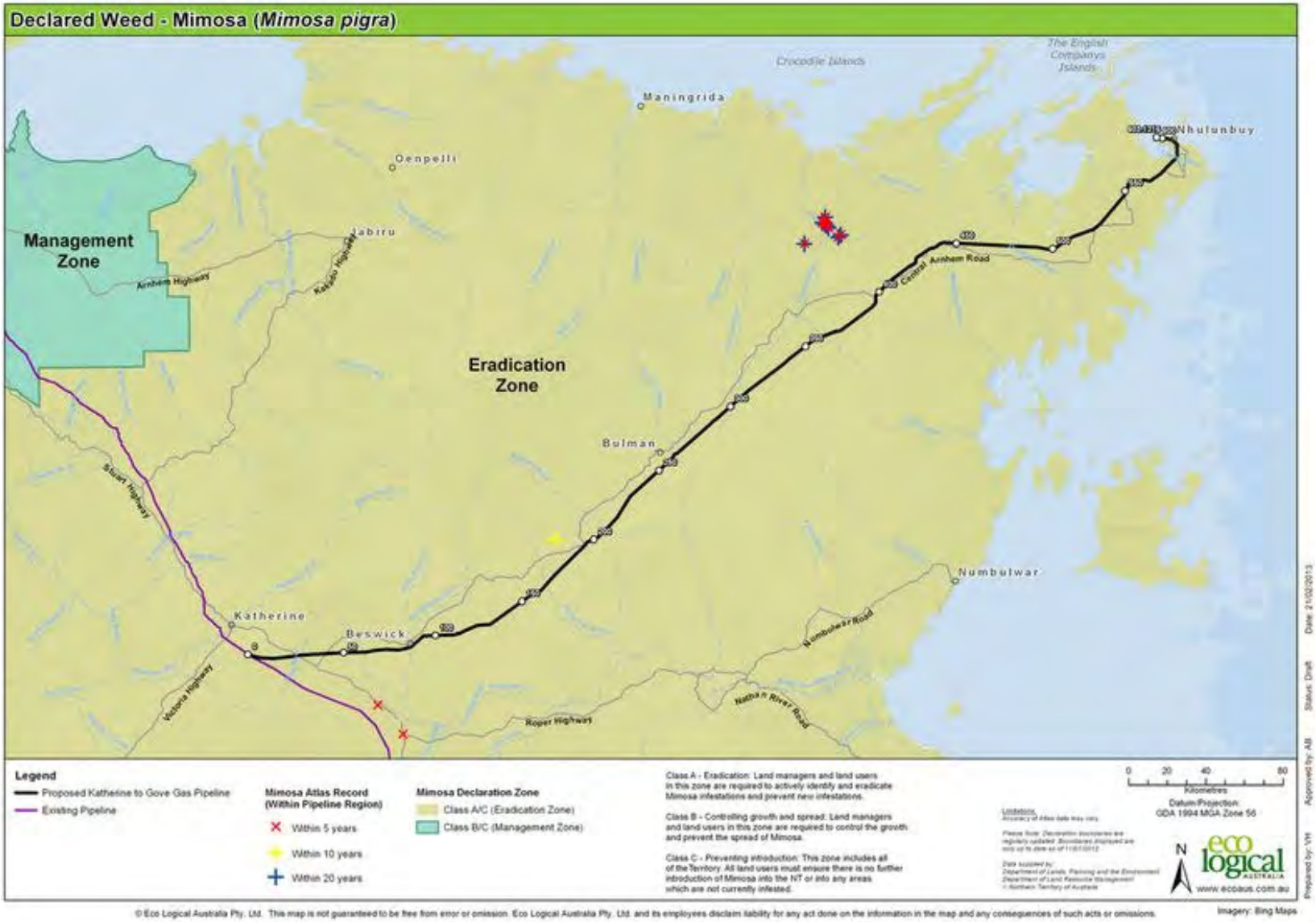

Figure 8-9: Location of Mimosa within the pipeline region

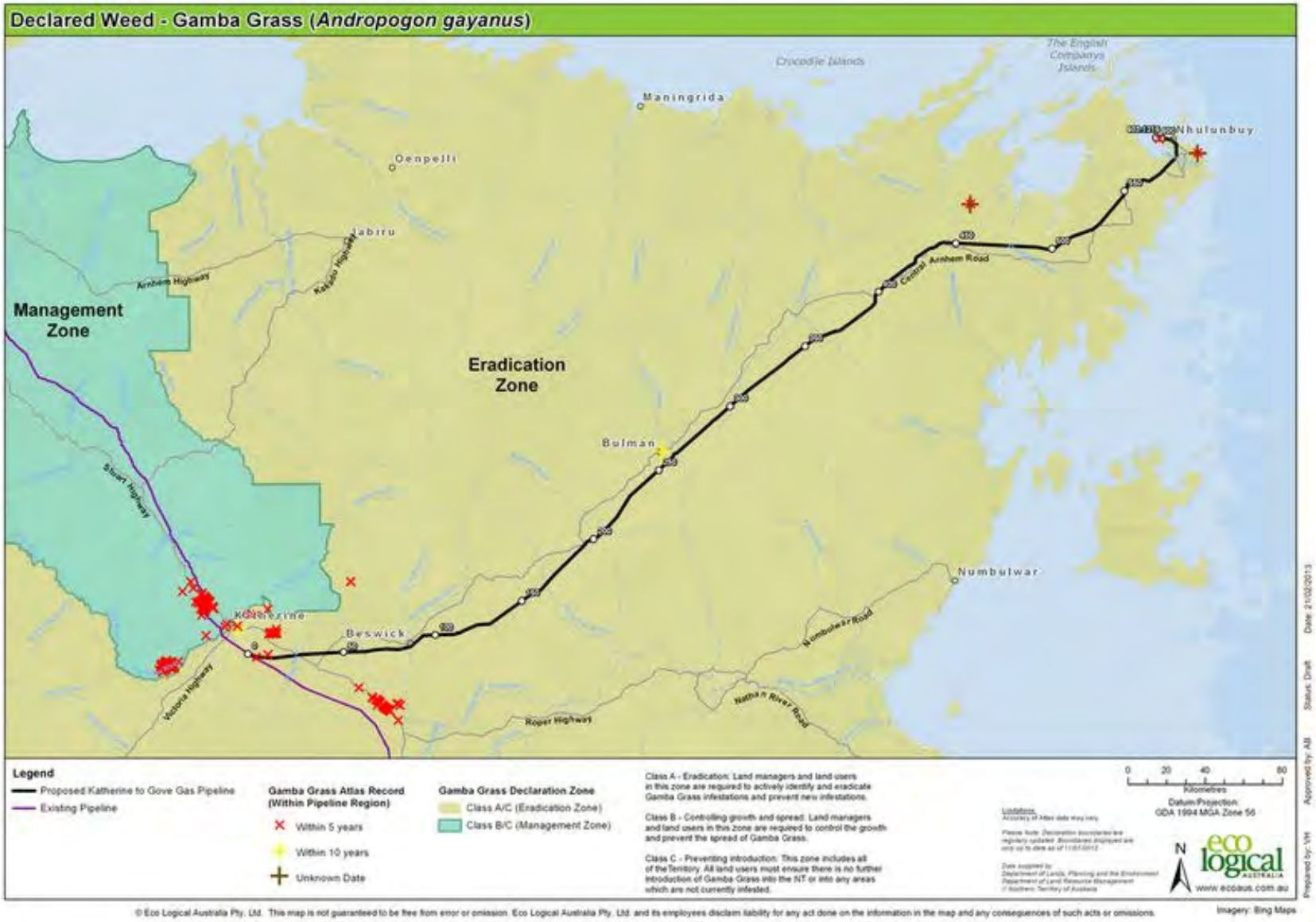

Figure 8-10: Location of Gamba Grass within the pipeline region

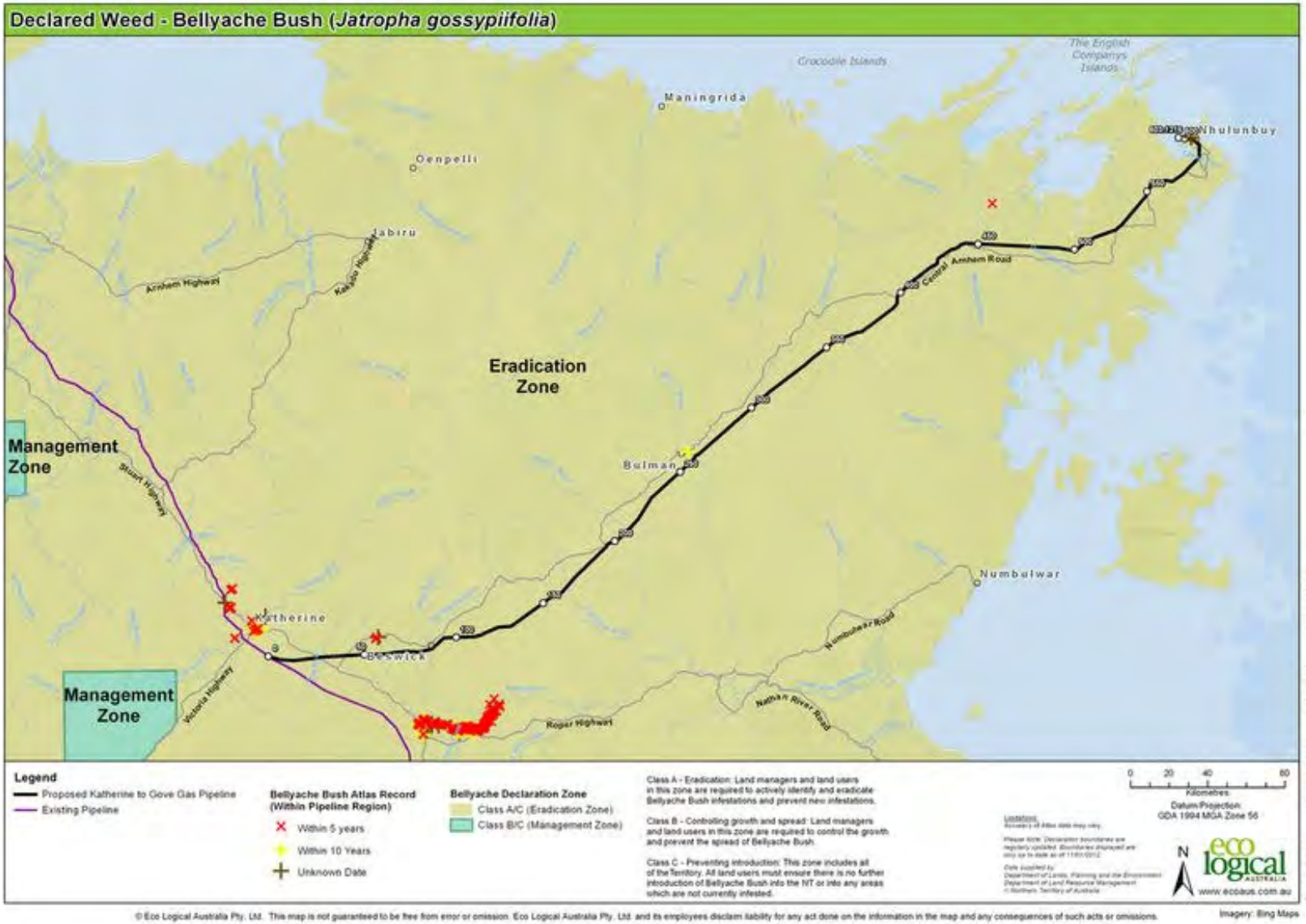

Figure 8-11: Location of Bellyache Bush within the pipeline region

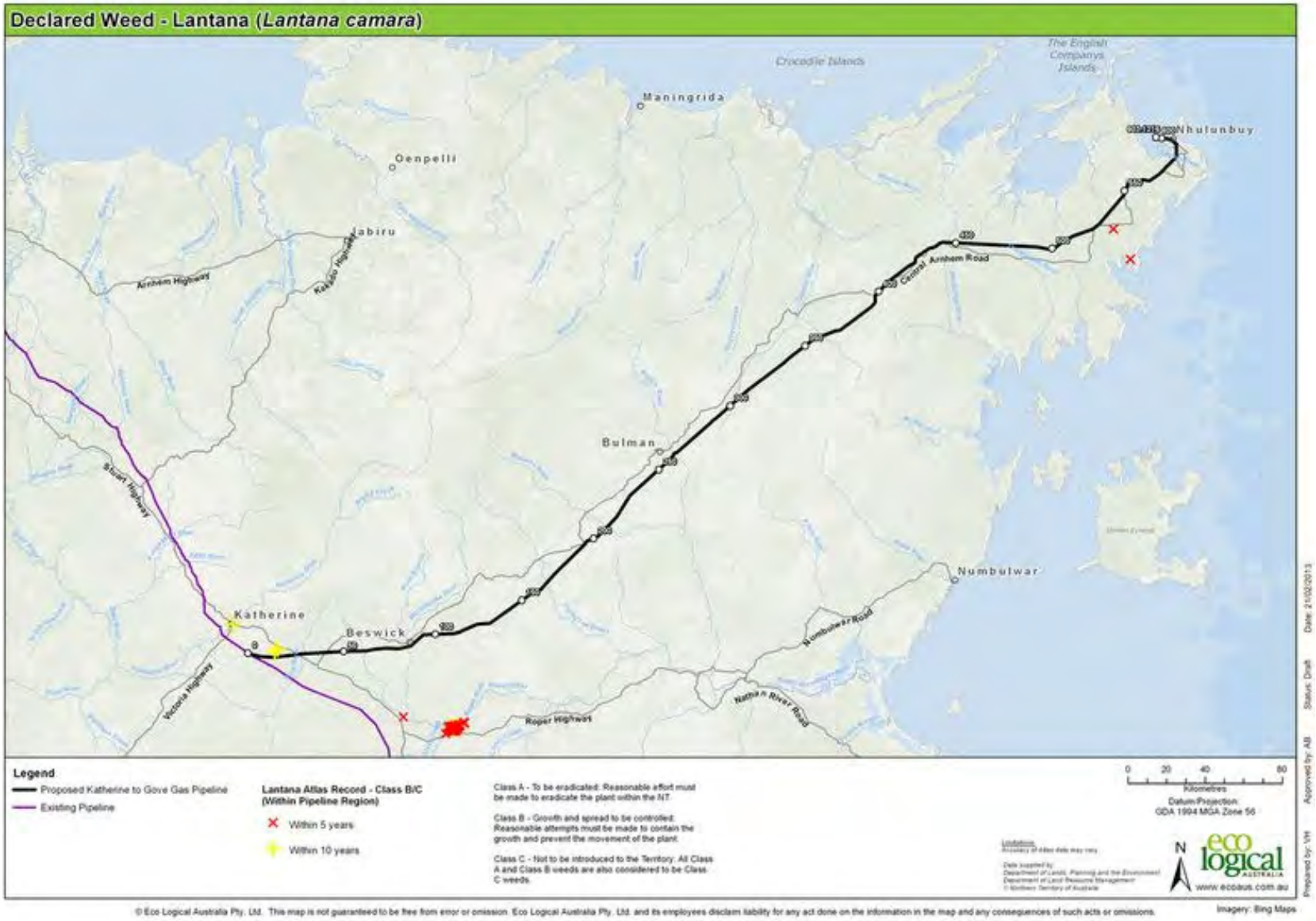

Figure 8-12: Location of Lantana within the pipeline region

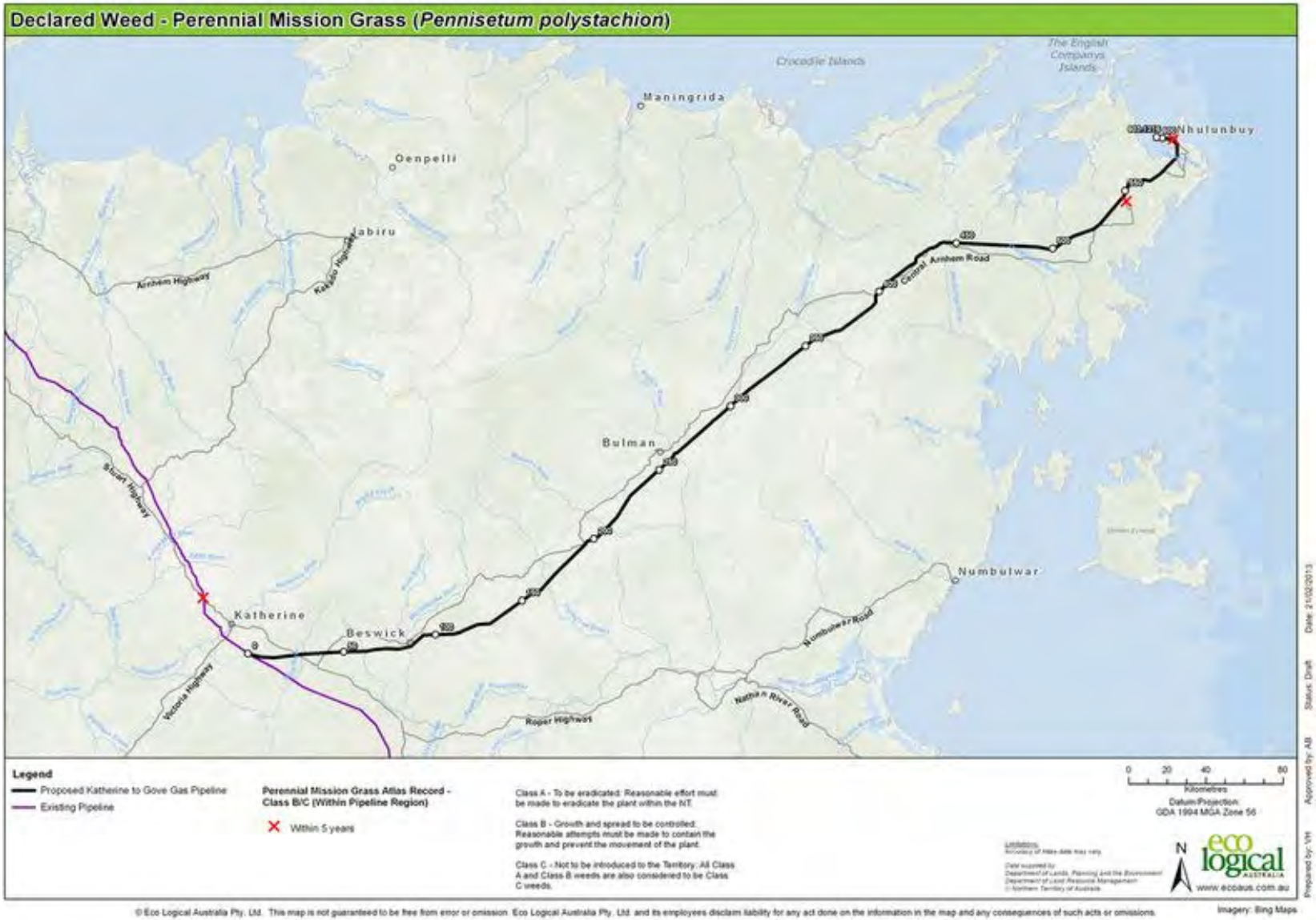

Figure 8-13: Location of Mission Grass within the pipeline region (including field survey locations)

- Water use/groundwater extraction.
- Liquid and solid waste disposal.
- Spills and leaks.
- Physical presence of infrastructure.

Each of these environmental aspects is defined for this project in Section 5.

8.3 MITIGATION RESPONSE AND ASSESSMENT OF POTENTIAL IMPACTS

An assessment of the potential impacts on vegetation as a result of the project, and key proposed mitigation responses to minimise these impacts is presented in the following sections and summarised in Table 8-3. A full outline of the management and mitigation measures to be implemented as part of the project is provided in the EMP (Appendix O).

8.3.1 Vegetation clearing

The establishment of the project would require clearing of up to 2,200 ha of native vegetation. Within this development envelope, approximately 1,850 ha would be cleared for construction of the 30 m wide pipeline ROW, approximately 180 ha would be cleared for ancillary infrastructure and approximately 170 ha would be cleared for construction of access tracks.

All trees and woody shrubs would be cleared within the ROW. In accordance with the Rehabilitation Management Plan (Appendix O), disturbed areas will be revegetated with a dense cover of appropriate native grasses based on the level of risk and reasonable expectations of relevant landholders. Criteria associated with the risk of erosion, weed infestation, slope and soil type would be developed to identify disturbed areas that require revegetation with native grasses. The majority of the cleared area within the ROW (approximately 60% or 1,110 ha) is expected to return to native woody vegetation over time, largely though natural regrowth once construction is complete. Deep rooted trees would not be allowed to grow or re-establish above or immediately adjacent to the pipeline as they would impact the pipeline's integrity. This area of the ROW (40% or 740 ha) would be either revegetated with native grasses, allowed to naturally regenerate with grass species or would be left as access track, once control measures outlined in the Rehabilitation Management Plan are implemented.

Ancillary support infrastructure to be located within the ROW includes one meter station, three scraper stations and five main line valves. The meter station would be fully contained within the ROW; however, the scraper stations and main line valves extend slightly beyond the ROW to maintain firebreaks. The compressor station located at KP23.6 (King River) would require an additional 25 ha to be cleared for construction with approximately 80% of this area (20.9 ha) to be rehabilitated and returned to native woody vegetation. Five construction camps would be required during construction, each with a development footprint of 25 ha (total 125 ha cleared). All of the area required for construction camps would be rehabilitated to native woody vegetation following construction.

Approximately 170 ha are proposed to be cleared for construction of access tracks (110-150 km) and borrow pits, of which 50% would be rehabilitated following construction. Where ever possible existing tracks and borrow pits would be used to minimise the amount of vegetation clearing required for access. The location of access tracks would be finalised in the detailed design phase. Prior to construction of access tracks, Pacific Aluminium will conduct flora, fauna and heritage evaluations of areas through which these roads will be placed, including desktop study and targeted pre-clearing inspections ahead of construction, to identify the following areas or features requiring consideration in management of construction:

- Areas or features of high conservation significance.
    - Vegetation representative of the Arnhem Plateau Sandstone Shrubland TEC.
    - Known, likely or potential critical, regionally significant and/or locally restricted habitat for threatened and/or migratory species listed under Territory or Commonwealth legislation.
    - Sites of archaeological or cultural heritage significance.
- Other areas requiring consideration for environmental management.
    - Sensitive habitat such as wetlands, monsoonal rainforest, melaleuca forest, or riparian vegetation.
    - Major weed infestations.
    - Sites of Yellow Crazy Ant infestation.
    - Highly erodible soils.
    - Flood prone areas.

Within six months of completion of construction, Pacific Aluminium will submit a Final Access Road Alignment Summary Report to both NT and Commonwealth Governments, demonstrating how the access tracks were designed and constructed to:

- Avoid direct disturbance of areas or features of high conservation significance
- Avoid, unless not reasonably practicable, and take into account other areas requiring consideration for environmental management.

The Summary will indicate those access roads, or parts thereof, that would be temporary and how these have been or are in process of being rehabilitated following construction

Disturbance/loss of significant vegetation communities

The vegetation communities that would be most affected by vegetation clearing within the ROW are woodlands and open woodlands dominated by *Eucalyptus miniata* and *E. tetrodonta*. Associations of this broad vegetation group are the most common in the Top End of the NT, and they characterise over 56% of the pipeline ROW. Woodlands dominated by associations of *E. tectifica* and *Corymbia* spp. are the second most common broad vegetation group in the project area comprising over 24% of the current pipeline ROW.

Vegetation communities mapped as broad vegetation groups and vegetation units of the Australian tropical savannas (Fox *et al*. 2001) that would be cleared within the ROW are listed in Table 8-3.

The Arnhem Plateau Sandstone Shrubland Complex is listed as threatened ecological community under the EPBC Act. Potential impacts on this ecological community are addressed in Chapter 10 along with other Commonwealth Matters of National Environmental Significance.

The pipeline alignment was modified in early design stages to avoid vegetation communities that are most restricted in areal extent and most sensitive to disturbance (i.e. ecologically sensitive habitats such as riparian corridors). As identified in Appendix C there are however, 26 major watercourses in or near the proposed pipeline corridor. The total amount of riparian vegetation associated with these watercourses and within the proposed corridor is 14 ha.

Horizontal Directional Drilling (HDD) and open-trenching and are the preferred construction methods for crossing watercourses. HDD minimises surface disturbance and substantially reduces any potential impacts to riparian vegetation (see Section 2.6.5 for more detail). Nine watercourses have already been identified as potentially requiring HDD for ecological, engineering and landholder

reasons (Table 2-6). HDD would also be used at any watercourse that is determined to be 'in flow' by the construction contractor at the time of constructing the crossing. Therefore, of the total 14 ha of riparian vegetation, at least six hectares will not be cleared as HDD crossing techniques would be employed (the nine crossings already identified). Hence the maximum amount of riparian vegetation associated with the 26 major watercourses identified in Appendix C that would possibly be cleared is eight hectares. It is, however, likely that much less than eight hectares will be cleared as other watercourses that are 'in flow' (other than minor flow) when the pipeline is to be laid, will also be crossed using HDD

Although Appendix C indicates that Beswick Creek would be crossed using HDD, subsequent review has suggested that this creek might not be in flow across the pipeline route when the crossing is to be done. Therefore, consistent with the project's overall approach regarding watercourse crossings, if Beswick Creek is not in flow, this watercourse would be crossed using open trenching.

None of the communities listed in Table 8-3 are identified as Threatened under the TPWC Act. The vegetation communities cleared for the ROW and construction camps would be revegetated and wherever possible, rehabilitated using the species and composition of the cleared community. The extent of clearing that associated with the construction of the pipeline is unlikely to have a substantial impact on vegetation communities once mitigation and management measures are implemented.

Vegetation clearing within the project area would be managed through a Vegetation Management Plan (Appendix O). Measures prescribed in the Vegetation Management Plan, combined with the low percentage loss of vegetation communities in their regional context due to clearing, would effectively manage vegetation clearing associated with the project.

Loss/removal of threatened species and conservation significant species

The likelihood of occurrence of Threatened flora species within the pipeline region through desktop review and field survey are listed in Table 8-2. Two species (*Hernandia nymphaeifolia* and *Sticherus flabellatus* var. *compactus*) are considered to possibly occur and one species (*Pternandra coerulescens*) is considered likely to occur.

Hernandia nymphaeifolia (listed as Vulnerable under the TPWC Act) is an exclusively coastal shrub or tree species that has only been recorded from eastern Arnhem Land near Port Bradshaw and Groote Eylandt (Kerrigan and Cowie 2006a). The species was not recorded during field survey and the known records near Port Bradshaw occur outside the ROW (approximately 20 km south-east of the pipeline). It is considered that there would be no disturbance and/or loss of *Hernandia nymphaeifolia* individuals due to vegetation clearing.

Pternandra coerulescens (listed as Vulnerable under the TPWC Act) is known to occur at locations along the Latram River, Giddy River and Cato River (Kerrigan and Cowie 2012; Figure 8-5). Watercourse crossings for the project across these rivers are proposed to be constructed using HDD techniques. The use of HDD techniques substantially reduces the impact on riparian vegetation and as such, reduces the potential impact of vegetation clearing on this species. Based on the lack of observations during field survey in the preferred habitat of *P. coerulescens* and the location of recent records, it is considered unlikely that the species would occur within the ROW and so be subject to disturbance and/or loss of individuals due to vegetation clearing. However, inspections would be undertaken prior to the commencement of river crossing construction to confirm the absence of this species in areas to be disturbed. If any individuals were unexpectedly found, construction methods would be reviewed to avoid individuals where practicable. If avoidance was not possible, remedial actions would be investigated to mitigate the removal of individuals.

Table 8-3: Clearing calculations according to vegetation groups and units traversed by the pipeline ROW (based on Fox et al. 2001).

BROAD VEGETATION GROUP	VEGETATION UNIT	AREA CLEARED WITHIN ROW (HA)	EXTENT OF AREA IN 100 KM PIPELINE REGION (HA)	% OF ROW	% OF PIPELINE REGION CLEARED WITHIN ROW
Woodlands and open-woodlands dominated by *Eucalyptus tetrodonta* and *E. miniata*	*Eucalyptus miniata* (Darwin Woollybutt) and *Eucalyptus tetrodonta* (Darwin Stringybark) +/- *Corymbia nesophila* (Melville Island Bloodwood) open-forest with *Sorghum* spp. (Sorghum) tussock grasses.	634	1,367,339	35	0.05
	Eucalyptus tetrodonta (Darwin Stringybark) and *Eucalyptus miniata* (Darwin Woollybutt) +/- *Corymbia bleeseri* (Rusty-barked Bloodwood) with *Sorghum* spp. tall-grasses.	203	921,876	11	0.02
	Eucalyptus tetrodonta (Darwin Stringybark), *Eucalyptus miniata* (Darwin Woollybutt) +/- *Corymbia* spp. +/- *Livistona* spp. (Fan Palms) woodland with a ground layer of tussock grasses and *Triodia bitextura* (Curly Spinifex).	85	550,842	5	0.02
	Eucalyptus tetrodonta (Darwin Stringybark) and/or *Melaleuca viridiflora* (Broad-leaved Teatree) +/- *Callitris intratropica* (Northern Cypress Pine) woodland with *Triodia bitextura* (Curly Spinifex) hummock grass.	88	221,845	5	0.04
	TOTAL	**1010**	**3061902**	**56**	**0.13**
Open forests and woodlands dominated by *Eucalyptus* spp. and *Corymbia* spp. on drainage lines and alluvial plains	*Eucalyptus camaldulensis* (River Red Gum) and/or *Eucalyptus microtheca* (Coolibah) or *Eucalyptus coolabah* (Coolibah) or *Eucalyptus gymnoteles* (Coolibah) woodland on channels and levees.	27	77,257	1	0.03
	Eucalyptus microtheca (coolibah) or *Eucalyptus gymnoteles* (Coolibah) and/or *Eucalyptus* spp. +/- *Excoecaria parvifolia* (Gutta Percha) grassy low woodland.	36	128,095	2	0.03
	TOTAL	**63**	**205,352**	**3**	**0.06**

BROAD VEGETATION GROUP	VEGETATION UNIT	AREA CLEARED WITHIN ROW (HA)	EXTENT OF AREA IN 100 KM PIPELINE REGION (HA)	% OF ROW	% OF PIPELINE REGION CLEARED WITHIN ROW
Woodlands dominated by *Eucalyptus tectifica* and *Corymbia* spp.	*Eucalyptus tectifica* (Darwin box) and/or *Corymbia* spp. woodland with *Sorghum* spp.(Sorghum) and *Sehima nervosum* (White Grass) tussock grasses.	427	1,180,317	24	0.04
Low woodlands to open woodlands dominated by *Corymbia dichromophloia*	*Corymbia dichromophloia* (Variable-barked Bloodwood), *Eucalyptus miniata* (Darwin Woollybutt) +/- *Eucalyptus tetrodonta* (Darwin Stringybark) open-woodland with *Triodia bitextura* (Curly Spinifex) and *Sorghum* spp. grasses.	96	480,120	5	0.02
Woodlands dominated by *Eucalyptus pruinosa* and *Bauhinia cunninghamii*	*Eucalyptus pruinosa* (Silver Box) +/- *Lysiphyllum cunninghamii* (Bauhinia) low open-woodland +/- a shrub layer and tussock grasses or *Triodia* spp. (Spinifex).	129	254,658	7	0.05
Acacia shirleyi and *Acacia* spp. associations on dissected residual surfaces and sandstone hill	*Acacia shirleyi* (Lancewood) and/or other *Acacia* spp. and/or *Eucalyptus* spp. low woodland with short tussock grasses and/or *Triodia* spp. (Spinifex) hummock grasses.	51	112,477	3	0.05
Tussock grasslands	*Dichanthium fecundum* (Curly Bluegrass) and *Chrysopogon fallax* (Golden Beard Grass) tussock grassland sparsely wooded with low trees.	25	16,643	1	0.15
Open forests and woodlands of *Melaleuca* spp. associated with rivers, lagoons and swamps	*Melaleuca* spp. (Paperbark) open-forest.	4	27,276	0.2	0.02

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The small, terrestrial fern, *Sticherus flabellatus* var. *compactus* (listed as Vulnerable under the TPWC Act), is known to occur in the pipeline region from only two records dating back to 1988, where it was found on sandstone cliffs in riparian vine forests in northeastern Arnhem Land (Kerrigan and Cowie 2006; Figure 8-6). Based on the location of known records (i.e. approximately 10 km from the pipeline) and lack of observations during field survey, it is considered that this species is unlikely to occur within the ROW and therefore would not be subject to disturbance and/loss of individuals due to vegetation clearing.

Small stands of *Callitris intratropica* (a species of conservation significance) and individual trees were observed during field surveys between KP17 and KP54. While retention of this species is recommended where possible, it is likely that individuals would be lost during construction. This species is not protected under the TPWC Act and field survey suggests there are no large stands within the project area (Appendix C). There are a substantial number of records of *C. intratropica* along the Central Arnhem road in eastern Arnhem Land, particularly where the road runs parallel to the pipeline alignment (KP350-KP450), suggesting that the loss of individuals within the ROW due to vegetation clearing would be unlikely to significantly impact their population within Arnhem Land, or across the Top End.

The Management Program for Cycads identifies land clearing as a potential threat to all cycads (Liddle 2009). Two cycad species of conservation significance were identified within the pipeline corridor: *Cycas orientis;* and *C. arnhemica*. Neither of these species is protected under the TPWC Act nor the EPBC Act. Each of these species was observed within the ROW east of the Goyder River through north-east Arnhem Land to commonly form a significant component of the understorey vegetation in the *Eucalyptus* woodland/forest communities (Appendix C). It is likely that some individual cycads would be lost due to vegetation clearing in the ROW during construction of the pipeline. However, both species occur in substantial numbers to the north and east of the pipeline alignment and this loss is considered unlikely to significantly impact their populations within Arnhem Land. The commercial value of these species is widely recognised and the potential for salvaging plants either removed during the clearing process, or prior to their removal, will be considered in consultation with land owners (Appendix C).

Surveys and the desktop assessment did not identify any ecologically significant or Threatened aquatic flora that would be impacted by vegetation clearing. Appropriate management measures for the construction of watercourse crossings using HDD and trenching through areas of waterlogged soils, would reduce the potential for the ROW to negatively impact aquatic species within wetlands and watercourses of the pipeline alignment.

There is no vegetation clearing associated with the operational phase of the project.

Mitigation and management measures summarised in Table 8.6 and prescribed in the Vegetation Management Plan (Appendix O), combined with the lack of records of occurrence within the ROW, indicate that Threatened or conservation significant species would be unlikely to be impacted by vegetation clearing.

Fragmentation and degradation of vegetation communities

Within the pipeline project area, fragmentation is likely to occur in close association with vegetation clearing. Areas more susceptible to fragmentation and habitat degradation within the project area include those immediately adjacent to the ROW and along access tracks. A 30 m wide ROW would not be a barrier to natural seed fall and dispersal. Over the longer term it would be expected that approximately 60% of the ROW would return to native woody vegetation. Revegetation limits the

potential for fragmentation in terms of bisecting vegetation communities, and impacts to the vegetation communities would be negligible.

The impact of fragmentation that is of most concern is the potential introduction and spread of weed species (particularly those that are fire-prone) during construction and rehabilitation of cleared areas. Also, erosion issues may arise if the area is not adequately revegetated and managed.

Increased susceptibility of the introduction and spread of weeds is discussed further in Section 8.3.2.

Increased susceptibility to erosion following trenching is addressed in Section 6.3.

Impacts from fragmentation and degradation of vegetation communities are considered unlikely following the implementation of mitigation and management measures prescribed in the Vegetation Management Plan (and summarised in Table 8.6). Rehabilitation and revegetation of the pipeline ROW would substantially reduce any further potential negative impacts on the vegetation communities located within and surrounding the ROW.

8.3.2 Introduction and spread of exotic species

The project has potential to transport weed species to areas that are currently mostly weed free, particularly through the northeast of Arnhem Land. The construction phase of the project poses the greatest threat of introducing weeds and spreading existing weeds due to the high level of disturbance associated with vegetation clearing, disturbance to the topsoil, earthworks, and vehicular traffic to and from the ROW, including the transportation of plant and construction material and large numbers of workers entering the project area. The operational phase, including the maintenance of the pipeline, also has the potential to assist in the spread of exotic species through vehicular and human movement (albeit less frequently) during maintenance activities.

Of particular concern for the project is the establishment of Gamba Grass (*Andropogon gayanus*) (and other fire-prone weed species) along the pipeline ROW. This species is highly invasive and able to negatively impact savanna landscapes without adequate management (NRETAS 2010). Gamba Grass seed is able to be spread via wind, water, livestock, other animals (e.g. feral pigs) and machinery contaminated with seeds (NRETAS 2010). Gamba Grass was listed as a declared weed species in 2008 under the NT *Weeds Management Act* and is a WONS. Mission Grass (*Cenchrus polystachios*) also provides an increased fuel load for hot, late dry season fires if left unmanaged and was observed during field surveys in the KP120-240 range (Appendix C). Within the last five years, Gamba Grass has been recorded in the vicinity of Katherine (near the tie-in location) and Gove (refer to Figure 8-10), which are most likely to be potential risk areas for the spread of this species. Mission Grass records within the last five years indicate the greatest potential for spread to be in eastern Arnhem Land (refer to Figure 8-13). Other weed species with the potential to spread within the project area include:

- Prickly Acacia (records <5 years old centred around the Bulman area on the Central Arnhem Road, refer to Figure 8-7).
- Parkinsonia (records <5 years old located in Katherine, approximately 20 km north of the tie-in location and along the Roper River, approximately 40 km south of the pipeline, refer to Figure 8-8).
- Mimosa (records <5 years old located approximately 30 km south of the pipeline on the Stuart Highway and at the junction of the Stuart Highway and Roper Highway, refer to Figure 8-9).
- Bellyache Bush (records <5 years old occur near Beswick, refer to Figure 8-11).

- Lantana (records <5 years old located south of the Central Arnhem Road in eastern Arnhem Land, and along the Roper River, refer to Figure 8-12).

Weed species of most concern based on their proximity to the pipeline include Gamba Grass, Mission Grass, and Prickly Acacia. Based on records within the last 5 years, the remaining weeds are located at distances >10 km from the pipeline, reducing the potential for their spread within the project area.

Disturbance/loss of significant and threatened species and vegetation communities

The introduction and spread of weeds within the project area has the potential to degrade habitat values for listed Threatened flora species (*Hernandia nymphaeifolia*, *Pternandra coerulescens*, *Sticherus flabellatus* var. *compactus*), species of conservation significance (such as *Callitris intratropica*, *C. orientis* and *C. arnhemica)* and general vegetation communities.

Weed invasion threatens terrestrial biodiversity generally, leading to a potential decline in both species and habitat diversity. Parts of the project area already impacted by weeds such as Gamba Grass, Mission Grass and Prickly Acacia, are known to occur in proximity to the pipeline alignment.

The species most susceptible to disturbance and/or loss of individuals due to weed infestations is the small fern *Sticherus flabellatus* var. *compactus* (Kerrigan and Cowie 2006). Cycads and other species may be indirectly affected by the invasion of exotic grasses through their capacity to increase the fuel load (e.g. Gamba Grass) leading to intense fires (Liddle 2009). The potential impact of fire on cycads is discussed further in Section 8.3.3.

The potential impacts of weeds will be managed within the project area through a Weed Management Plan. Mitigation and management measures summarised in Table 8-4 and prescribed in the Weed Management Plan (Appendix O) would be required during the construction and operation phase to reduce the potential introduction and spread of weeds.

Due to the aggressive nature of the weeds identified above, it is expected that even with mitigation and management measures in place, a low potential remains for threatened species, conservation significant species and vegetation communities to be significantly impacted by the introduction and spread of weeds.

8.3.3 Fire ignition – increased risk of fire

Contemporary changes in fire regime within the project area following cessation or minimisation of traditional Aboriginal land management practices (which used low intensity, patchy fires) to one of more intense, unmanaged wildfires has already impacted vegetation communities and flora species of the Top End. An increased risk of fire would compound the effect of these contemporary changes.

Fire scar mapping by the Department of Land Resource Management from 2004-2011 indicates annual burning along most of the pipeline alignment, with the most frequent occurrence around and to the east of Beswick (Figure 8-14). The eastern extent of Arnhem Land and stretches of land along the pipeline at KP150-200 and KP350-400 have experienced the most infrequent occurrence of fire, with one to five years burnt between 2004 and 2011 (Figure 8-14).

During construction, the greatest risk relating to fire is an increase in the number and spatial extent of fire events or in the fire intensity. One potential vector is the establishment of weeds with high fuel loads such as Gamba Grass and Mission Grass (see Section 8.3.2). Another is the generation of sparks from construction equipment and the use of flammable products and welders.

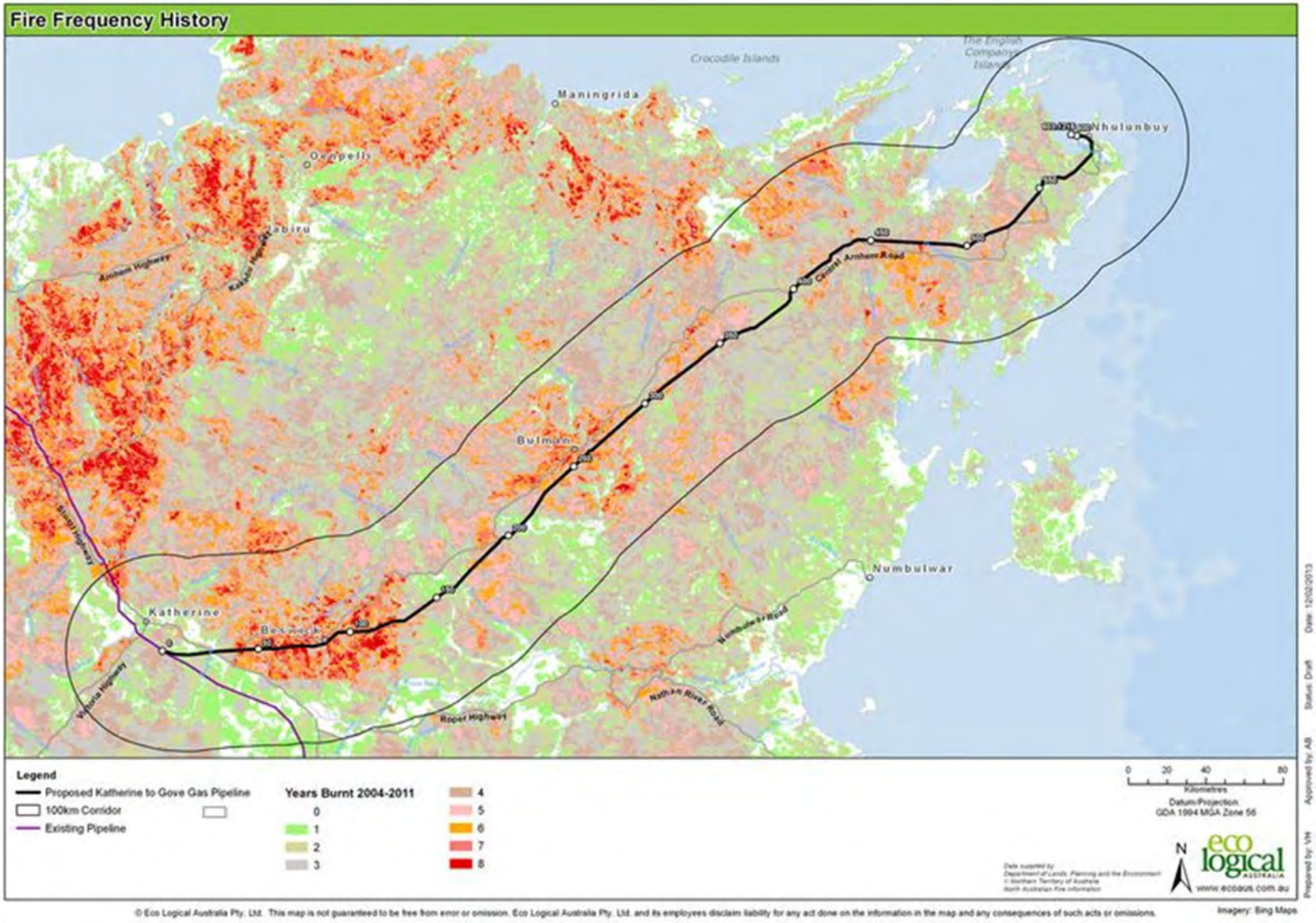

Figure 8-14: Fire frequency history between 2004-2011 for the pipeline region

Alternatively, there may be a short-term reduction in the occurrence or duration of wildfire during the construction phase as any detected source of potential wildfire near the pipeline corridor would likely be prevented or rapidly extinguished.

Either an increase or decrease in the fire regime would potentially alter the fuel load available, leading to changes in the soil stored seed and vegetation recovery following fire, which may also affect future fire intensities. Changes to the current fire regime within the project area may impact the structure and composition of vegetation communities, as well as pose a threat to infrastructure.

Disturbance/loss of significant and threatened species and vegetation communities

Fire has been identified as a threat for *Pternandra coerulescens*, *Callitris intratropica*, *Cycas orientis*, *C. arnhemica* and the Arnhem Plateau Sandstone Shrubland Complex (discussed in Chapter 10).

Pternandra coerulescens: The potential impact of fire on this species is largely unknown (Kerrigan and Cowie 2012). The individuals recorded within the pipeline region are clustered in the north-eastern extent of the pipeline corridor approximately one to two kilometres from the pipeline and ROW. This area is burnt less frequently than others within the pipeline corridor (refer to Figure 8-14). *Pternandra coerulescens* predominantly occurs in riparian zones and spring fed rainforests, which are also generally fire protected; however, fire in adjacent vegetation communities may occasionally affect rainforests and riparian zones. Adequate mitigation and management measures would substantially reduce the incidence of fire. It is considered that potential impacts from fire would have a negligible effect on this species and its NT population.

Cycas orientis, C. arnhemica: The recurrence of late dry season fires are one of the main threats to some cycad populations (Liddle 2009). Fire destroys existing seeds (Wesley-Smith 1973; Liddle 2004 as cited in Liddle 2009) and increases seedling mortality (Chirgwin 1990). Frequent burning may inhibit regeneration for cycads, while promoting seed production in other situations. Research undertaken on cycads examining the impact of various fire regimes revealed resilience of cycad populations to a broad range of fire frequencies. The occurrence of high intensity fire more frequently than once in five years resulted in population declines (Liddle 2009). The rapid spread of fire-prone exotic grasses in many Top End landscapes (Williams *et al.* 2001) poses a significant fire threat to cycads and reinforces the argument that landscapes supporting cycads require active management to avoid population decline (Liddle 2009).

Callitris intratropica: The Northern Cypress Pine is fire-sensitive and an obligate seeder (Russell-Smith, 2006). Mature trees have thick bark and can survive moderate but not intense fires while seedlings cannot survive even the mildest fire (Bowman and Panton, 1993). The distribution of Northern Cypress Pine is contracting to where seedlings are able to escape the impacts of fire (areas include rainforest margins and fire-protected microsites within savanna such as rocky outcrops and drainage lines) (Bowman *et al.* 2001; Russell-Smith 2006) following land management changes that shifted fires from low intensity, patchy burning to widespread high intensity wildfires (Whiteside and Taplin 2010). The widespread reduction in populations and the fragmentation of distributions may also be attributed to the change in fire regimes (Bowman and Panton, 1993; Bowman *et al*. 2001).

Cycads and the Northern Cypress Pine are species known to be sensitive to fire, particularly fire events that result in increased intensity and occurrence of fires (Liddle 2009; Bowman and Panton 1993).

The Northern Cypress Pine and both species of cycads identified above would be destroyed by intense fire; however, lower intensity fire may promote seedling establishment and germination. The few locations of individuals are situated within areas of Arnhem Land that are not burnt annually. This,

combined with the lack of significant populations of these species within the pipeline ROW, suggests it is unlikely that these species and their populations would be adversely impacted by fire.

Measures to avoid, mitigate and manage fire are considered necessary (Table 8-4). The implementation of a Fire Management Plan (Appendix O) will prescribe avoidance, mitigation and management measures to reduce the potential of fire within the pipeline ROW and region.

8.3.4 Additional environmental aspects

Vehicle movements

Vehicular activity has been briefly discussed in relation to the introduction and spread of weeds in Section 8.3.2. There would be an increase in vehicular traffic during the construction phase of the project; however, this would be restricted to discrete sections of the pipeline route at any one time. The construction phase would also comprise a higher number of access tracks which upon completion and operation of the project would be reduced to the minimum necessary for maintenance (refer to Section 8.3.1 for discussion of vegetation clearing associated with access tracks). Vehicular traffic during operation of the pipeline would consist solely of maintenance vehicles using designated access tracks.

Traffic would be managed within the project area through a Traffic Management Plan (Appendix O). Mitigation and management measures summarised in Table 8-4 and prescribed in the Traffic Management Plan would be implemented during the construction and operation phase to substantially reduce the potential impact of increased traffic on vegetation communities, including disturbance/loss of threatened species and conservation significant species. With these measures in place, it is considered highly unlikely that the communities or species would be impacted by increased traffic.

Dust emissions

Dust emissions would be a temporary component of the project during the construction phase and would be managed to satisfy human health criteria for the surrounding towns and human population (see Chapter 12).

There are currently no dust criteria relating to agriculture or native flora and fauna; however, research into the effects of dust on vegetation provides some indication of the relevance and severity of the impacts. Doley and Rossato (2010) established that a dust load (comprising dusts that are chemically inert and do not markedly alter substrate pH) greater than 500 mg/m^2/day could adversely impact plant growth. This research also found that rain events greater than 10 mm may completely remove the plant dust load; therefore, any deposited dust would be removed in the wet season following construction of the pipeline, with an approximate maximum period of overlay of seven months.

Dust emissions would be managed within the project area through the Air Quality Management Plan (Appendix O). Mitigation and management measures summarised in Table 8-4 and prescribed in the Air Quality Management Plan would be implemented during the construction and operation phase to substantially reduce the potential impact of disturbance and/or loss of vegetation communities, Threatened species and conservation significant species from deposition of dust. With these measures in place, it is considered highly unlikely that the communities or species would be impacted by dust deposition.

Liquid/solid waste disposal and spills and leaks

Liquid waste storage areas could potentially leak, causing degradation to surrounding vegetation, and dispersal from solid waste into areas outside designated disposal areas may also cause degradation. Discharge of hydrotest water may also degrade surrounding vegetation if not treated to remove

contaminants. Spills and leaks of hydrocarbon may be a potential issue, as higher usage volumes of these chemicals would be expected compared to others. This could result from failure of transport vehicle tanks, storage tanks or hoses.

Potential impacts from waste disposal and spills or leaks would be managed within the project area through the Waste Management Plan and the Hydrology and Water Quality Management Plan. (Appendix O). Mitigation and management measures summarised in Table 8-4 and prescribed in the Waste Management Plan (such as ensuring all storage for liquid and solid waste and chemicals are bunded) would be implemented during the construction and operation phase to substantially reduce the potential impact of disturbance and/or loss of vegetation communities, Threatened species and conservation significant species. With these measures in place, it is considered that any potential impacts from waste disposal and spills would be negligible.

Physical presence of infrastructure longer term impacts

The physical longer term presence of infrastructure (such as the compressor station, scraper stations, main line valves and access roads used during the operational phase of the project) may inadvertently pre-dispose areas to the spread of weeds and feral animals through changes in ground and canopy cover, resulting in degradation of vegetation communities.

Facilitation of the spread of weeds and feral animals would be managed within the project area through the Introduced Fauna Management Plan and Weed Management Plan (Appendix O). Mitigation and management measures prescribed in each of these plans and summarised in Table 8-4 would be implemented during the construction and operation phase to substantially reduce the potential for degradation of vegetation communities. With these measures in place it is considered highly unlikely that vegetation communities would be significantly impacted by weeds or feral animals.

8.3.5 Environmental Management Plans (EMPs)

All potential impacts to flora and vegetation would be mitigated through the implementation of measures summarised in Table 8-4 and described in the following EMPs for the project (Appendix O):

- Vegetation Management Plan.
- Weed Management Plan.
- Introduced Fauna Management Plan.
- Fire Management Plan.
- Traffic Management Plan.
- Air Quality Management Plan.
- Hydrology and Water Quality Management Plan.
- Waste Management Plan.

8.4 SUMMARY – PREDICTED ENVIRONMENTAL OUTCOME

After mitigation is applied, construction and operation of the KGGP is expected to result in the following outcomes in relation to vegetation:

- Development footprint for the project of up to 2,200 ha with approximately 60% to return to native woody vegetation over the longer term.
- No removal of known recordings of any listed threatened flora species.
- Minimal disturbance to conservation significant flora species.
- Minimal spread of weeds into the pipeline ROW.
- Progressive rehabilitation of the ROW.

(continued page 8-38)

Table 8-4: Mitigation measures for vegetation impacts during construction and operation

POTENTIAL IMPACT	PROPOSED MITIGATION (ACTION)		ANTICIPATED EFFECT OF MITIGATION
	AVOIDANCE	MINIMISATION	
Vegetation clearing, resulting in • Disturbance/loss of significant vegetation communities. • Loss/removal of threatened species and conservation significant species. • Fragmentation and degradation of vegetation communities.	• Listed threatened or conservation significant flora species observed in close proximity to the pipeline ROW will be flagged in the field and recorded as GPS coordinates in earthmoving equipment to prevent the disturbance of these species and access will be restricted where possible. • Personnel operating earth-moving equipment will be made aware of data on the locations of listed threatened and conservation significant flora species in close proximity to the pipeline ROW.	• Clearing will occur only within the approved disturbance area which will be clearly marked. • Clearing boundaries will be defined with ground marking (e.g. flagging) or as Global Positioning System (GPS) coordinates in earthmoving equipment in accordance with existing Pacific Aluminium Clearing permit procedure, prior to commencement of ground-disturbing activities to ensure that all personnel are aware of clearing limits. • Vegetation will be cleared and areas rehabilitated progressively throughout construction to minimise the period of disturbance. • Weed monitoring and control will be undertaken if necessary if weed distribution and abundance encroaches on listed threatened and conservation significant species and vegetation communities.	• Impacts would be localised and restricted within the ROW, without impact on regional representation of threatened species, species of conservation significance and vegetation communities. • Impacts would be minimised by the avoidance and minimisation measures applied, and implementation of targeted management plans. • No threatened species, species of conservation significance or vegetation communities are likely to be impacted by clearing of vegetation. • No fragmentation or degradation of vegetation or flora anticipated outside the ROW, and much of the ROW would be rehabilitated with all but deep rooting species.
Introduction and spread of exotic species Disturbance/loss of significant and threatened species and vegetation communities.		• The distribution and abundance of target weed species (including Gamba Grass, Mission Grass and Prickly Acacia) within the project area will be mapped, recorded, internally reported and monitored. • New weed infestations will be reported as they are discovered. • Hygiene measures will be implemented.	• Impacts on threatened species, species of conservation significance and vegetation communities from introduction or spread of weeds would be avoided by minimising incidents of introductions or spread, and quick and effective removal and treatment of any introductions.

POTENTIAL IMPACT	PROPOSED MITIGATION (ACTION)		ANTICIPATED EFFECT OF MITIGATION
	AVOIDANCE	MINIMISATION	
		• Induction and training of workers.	
Fire ignition (increased risk of fire) Disturbance/loss of significant and threatened species and vegetation communities.	• Open ground fires will be prohibited throughout the entire area (except for fire training purposes). • A coordinated approach to bushfire control will be developed with relevance to surrounding stakeholders. • All plant and equipment will be maintained and operated to comply with relevant fire safety standards. • Fire not to be used to clear vegetation. • Induction and training of workers.	• Fire fighting equipment will be maintained and operated to comply with relevant fire safety standards. • A Fire Management Plan and Weed Management Plan will be implemented with a focus on the reduction of fuel loads at the construction sites and the risk of uncontrollable fires especially in late dry season.	• Impacts on threatened species, species of conservation significance and vegetation communities would be avoided through avoiding ignition of fires, and rapid response to any fire inadvertently lit.
Vehicle movements Degradation/alteration of vegetation communities and disturbance/loss of threatened species and conservation significant species.	• Speed limit will be posted on site and along access roads and all project work areas. • Truck movements on the construction corridor and access tracks will take place during daylight hours where possible. • Induction and training of workers. • Vehicles will be required to remain on designated access tracks.		• No damage or destruction of vegetation communities or disturbance/loss of threatened species or species of conservation significance, through restricting vehicles to approved access tracks and appropriate training and induction of workers.
Dust emissions Disturbance and/or loss of vegetation communities, threatened species and conservation significant species.		• Ensure that vehicles, machinery and loads are properly maintained and covered to minimise dust emissions. • Regularly water unsealed roads, exposed ground surfaces and stockpiles	• No disturbance or loss of vegetation communities, threatened species or conservation significant species anticipated after proposed mitigation measures are applied.

POTENTIAL IMPACT	PROPOSED MITIGATION (ACTION)		ANTICIPATED EFFECT OF MITIGATION
	AVOIDANCE	MINIMISATION	
		with water tankers/carts using non-saline water or with an alternative approved substance.	
Water use/groundwater extraction Disturbance/loss of groundwater dependent vegetation.	• Water extraction to be consistent with the Water Supply and Adaptive Management Strategy (Chapter 7). • Hydrotest water will be disposed of by ground application in a stable environment following treatment to remove contaminants or to evaporation ponds.	• Work program undertaken and a water supply and adaptive management strategy to be developed and implemented.	• Water supply to the Project to have temporary and negligible impact on hydraulic regime and riverine ecology the project area.
Liquid and solid waste disposal Disturbance and/or loss of vegetation communities, threatened species and conservation significant species.	• Ensure all waste is contained appropriately, taking into consideration fire safety, pest and odour control, and protection of water and soil resources. • Fuel and chemical storage will be above ground and will be located an appropriate distance from surface waters and high quality groundwater resources.		• Self-contained sewage and wastewater systems, in addition to transport of solid wastes offsite, are expected to avoid deleterious impacts on flora and vegetation.
Spills and leaks Disturbance and/or loss of vegetation communities, general flora species, threatened species and conservation significant species.	• Construction crew will be trained in fuel handling and how to effectively contain and clean up spills. • Each construction site will have an approved emergency plan and spill kits to deal with accidental spills • All fuel and hazardous materials will be handled and stored in bunded areas in accordance with the corresponding Materials Safety Data Sheets (MSDS) and Australian Standards.		• Mitigation measures would be expected to avoid or minimise spills, or contain and treat any spills that could potentially impact vegetation; therefore, potential impacts on flora or vegetation from spills would be avoided or negligible.

POTENTIAL IMPACT	PROPOSED MITIGATION (ACTION)		ANTICIPATED EFFECT OF MITIGATION
	AVOIDANCE	MINIMISATION	
Physical presence of infrastructure Degradation of vegetation community due to spread of weeds and feral animals		• The locations of all work areas, will be accurately recorded so that they can be appropriately rehabilitated and monitored for weed infestations post construction	• Mitigation measures to minimise the potential to introduce and spread weeds or feral animals; to ignite fires; and minimise or avoid other threatening factors are expected to avoid or minimise impacts on vegetation.

- Negligible fragmentation or degradation of vegetation communities.
- Reduced potential of fire within the ROW and minimal impact from fire to listed threatened species and conservation significant species.
- Minimal impacts on vegetation from traffic, dust, groundwater drawdown, waste disposal and the presence of infrastructure.
- No impact on listed threatened or conservation significant flora, through avoidance and re-location of ancillary infrastructure.

Potential impacts to vegetation are expected to be negligible to low and therefore considered not significant.